Modeling, Simulation and Analysis for Life Cycle Decision Making

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Outline

- Motivation for Modeling, Simulation and Analysis (MSA) for Life Cycle Decision Making
- Sandia's System of System Analysis Toolset
- MSA during different Life Cycle Phases
  - Design Phase
  - Fielding Phases
  - Program Improvement Phases
  - Recap/Reset/Retirement Phase
- Conclusions

Motivation for Life Cycle MSA

- Too often MSA efforts throughout a program lifecycle are disjoint and adhoc
  - MSA efforts become difficult and costly
  - Long-term benefit of life cycle MSA reduced
- Benefits of Life Cycle MSA
  - Initial model development investment is leveraged across lifecycle
  - Model accuracy is increased as life cycle phases progress
- MSA can assist decision makers in:
    - Setting feasible design requirements
    - Mission and logistics planning
    - Force structure configuration
    - Recap/Reset/Retirement decision making

System of Systems Analysis Toolset (SoSAT) Background

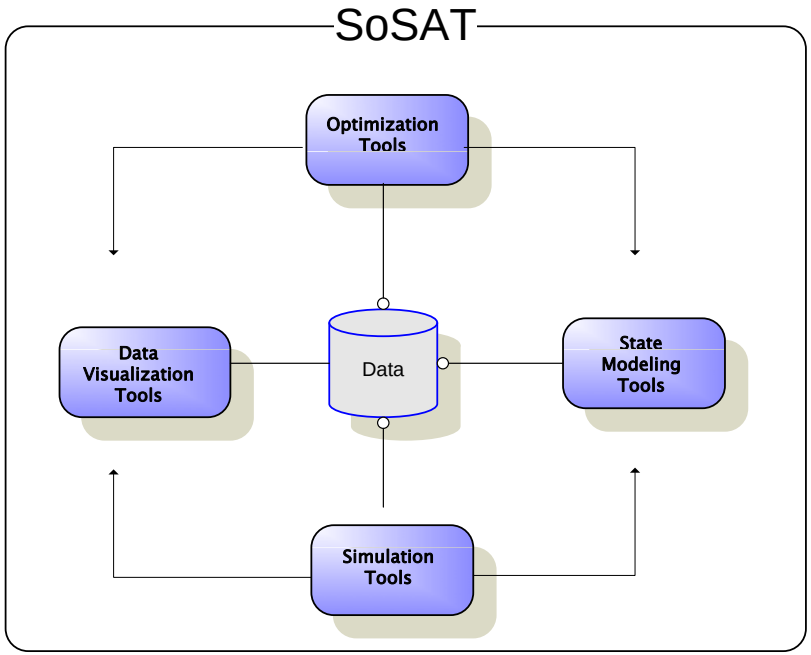
- SoSAT (System of Systems Analysis Toolset) is a suite of software tools:
  - State Model tool
  - Stochastic simulation tool
  - Advanced data visualization tools
  - Reliability, spares, and supply optimization tools

- Initially designed to provide DoD and supporting organizations the capability to analyze a System-of-Systems (SoS) and its various platforms
  - Supporting multiple US Army Future Combat Systems (FCS) trade studies
  - Influencing military system design decisions
  - Performing Assessment of Sustainment/Reliability Key Performance Parameters
    - Operational Availability (Ao)
    - Self-Sustainment (Spares, Ammo, Water, Fuel)
    - Footprint Reduction
  - US Army Program Executive Office of Ground Combat Systems (PEO GCS) is using SoSAT for Fleet Management and Modernization Planning initiative
  - Participating in formal Verification, Validation & Accreditation effort with Army Organizations

SoSAT Simulation v2.0 Released February 2010

SoSAT Capabilities

- SoSAT provides analysts the capability to:
  - Simulate *any or all* of a system of systems (SoS) organizational structure
  - Simulate multiple mission segments for a SoS
  - Provide data to assess SoS performance objectives
  - Support business decisions and trade-offs
- Basic Modeling Features
  - System element reliability failures
  - Consumable usage and depletion
  - Maintenance activities including any required spares or services
  - Supply reorder for consumables and spare inventories
- Advanced Modeling Features
  - Combat Damage Modeling
  - Network Modeling
  - Prognostics and Health Management
  - Time-Based changes to model attributes (External Conditions)
  - System Referencing (interdependencies)
- Active Model Development
  - Network & human modeling capability
  - Enterprise Modeling incorporation

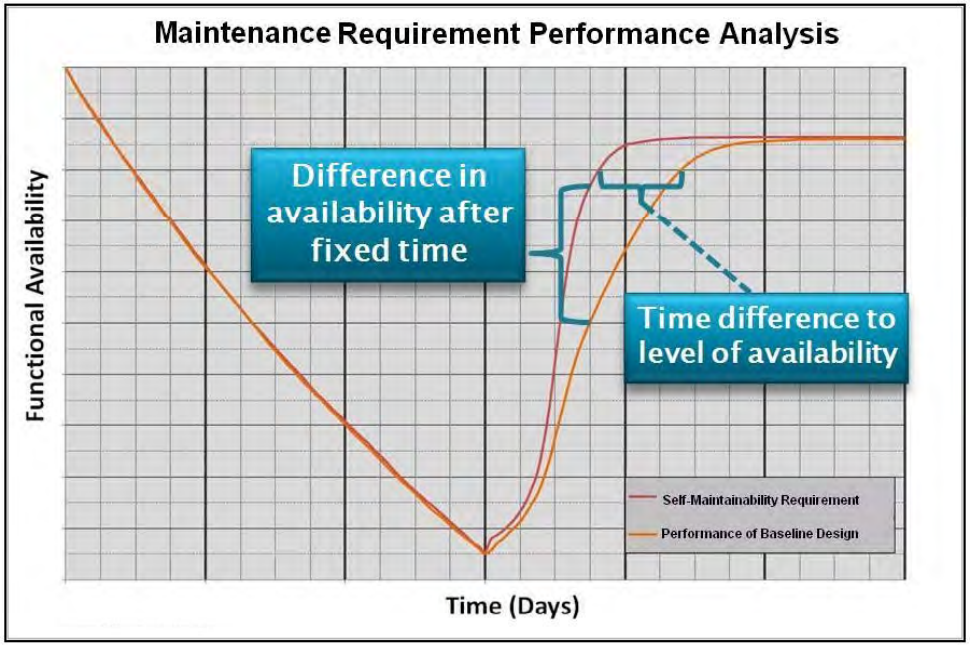


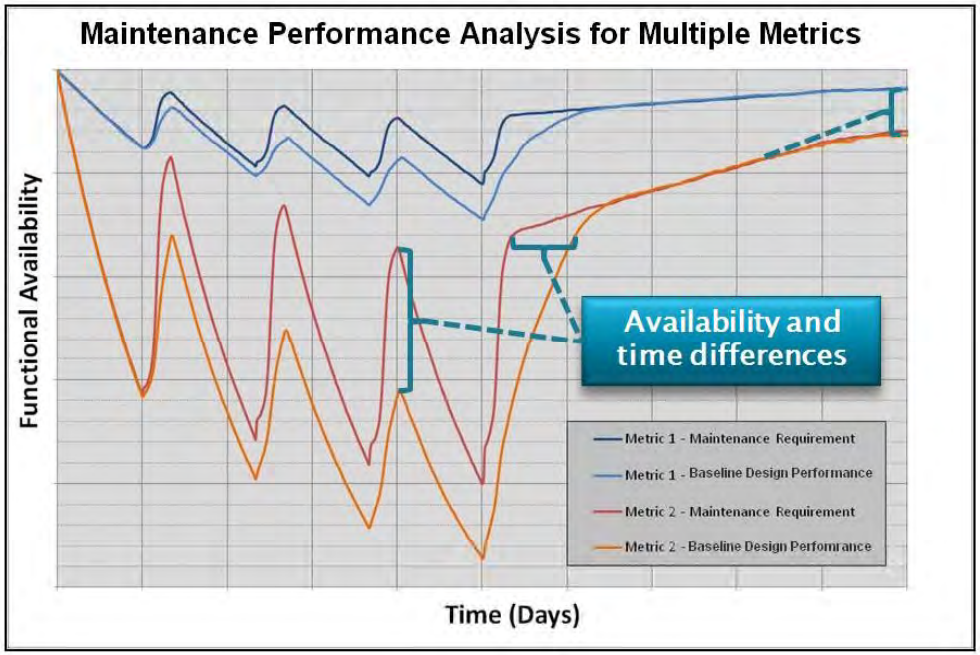
Design Phase MSA

- Evaluate system's ability to meet performance specifications and requirements, such as:
  - Operational Availability (Ao)
  - System maintainability and reliability
  - Cost
- Develop initial system of systems models
  - Leverage this investment throughout life cycle
- Use MSA to validate feasibility of design requirements
- Example: Maintainability Requirement

Maintenance Impact Study Overview

- Objective: Quantify impacts of not meeting the maintainability requirement for manned vehicles
- Metrics of Interest
  - Functional Availability over time
  - Time to recover after mission
- Model Scenarios
  - Single mission followed by long recovery
  - Multiple missions with short recovery followed by long recovery
- Major factors influenced by design
  - Reliability
  - Maintainability
  - Time to repair
- Other factors outside of design control
  - Spare availability
  - Number of maintenance resources
  - Competition for resources by other platforms
  - Platform utilization



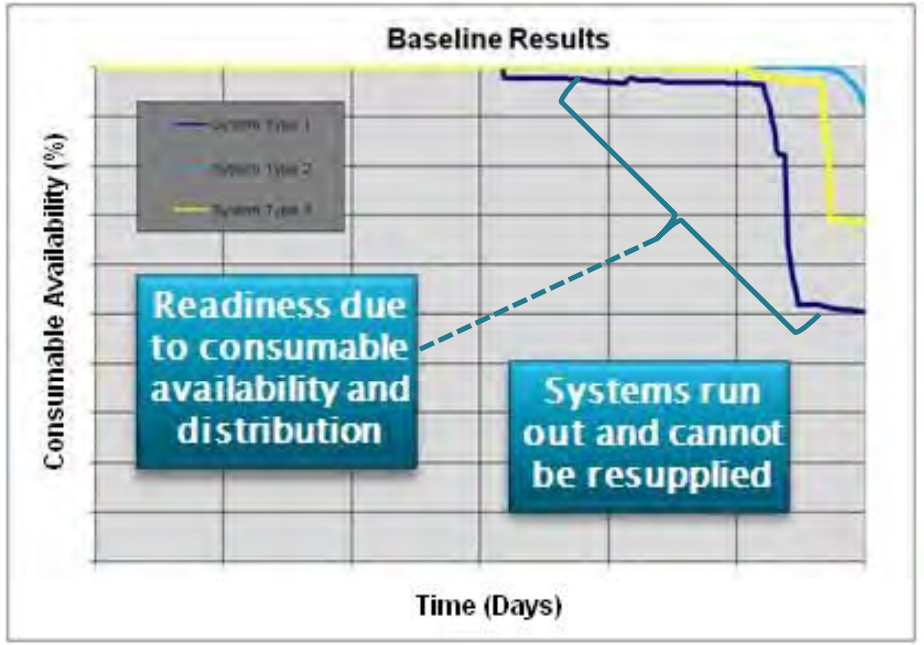


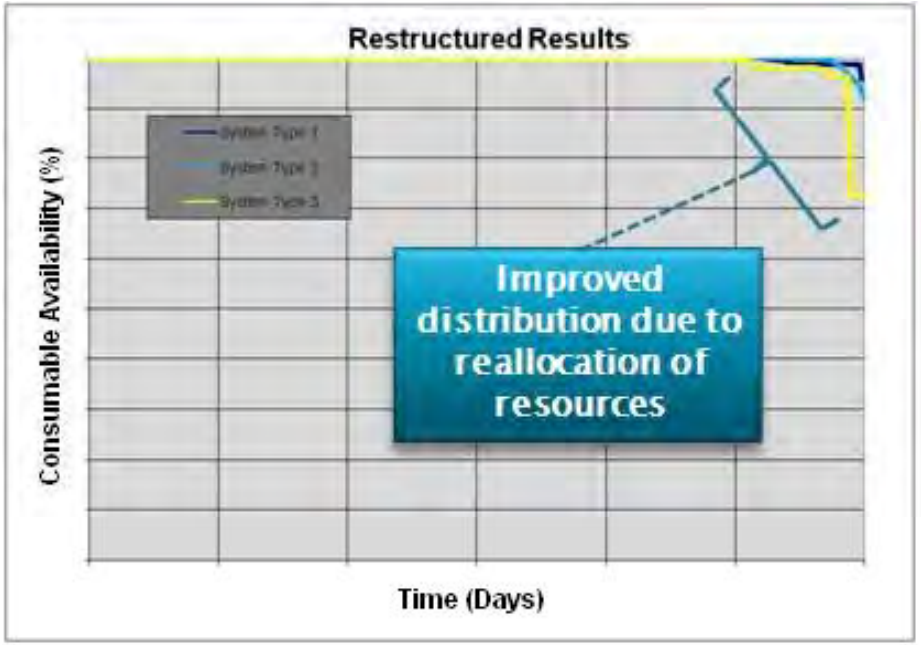
Fielding Phases

- MSA can assist in evaluating Operational Availability of fielded systems using existing models for:
  - Mission planning
  - Force structure configuration
  - Logistics planning
- Update models based on deployment strategies and field data
  - Fine tune model in terms of logistics supply chain, troop and system deployment decisions
- Example: Consumable Distribution Analysis

Consumable Distribution Study

- Objective: Determine number and location of distribution resources to sustain organization over mission
  - Minimize consumables within organization
  - Minimize distribution platforms
  - Evaluate distribution concepts of operations
  - Include reliability effects
- Model Scenarios
  - Single mission
  - Baseline –original distribution structure
  - Restructured – same number of distribution resources with different distribution locations
- Study Findings
  - Reliability and sustainment of distribution resources can have a large impact
  - Variable consumption rates over mission should be included to examine distribution performance

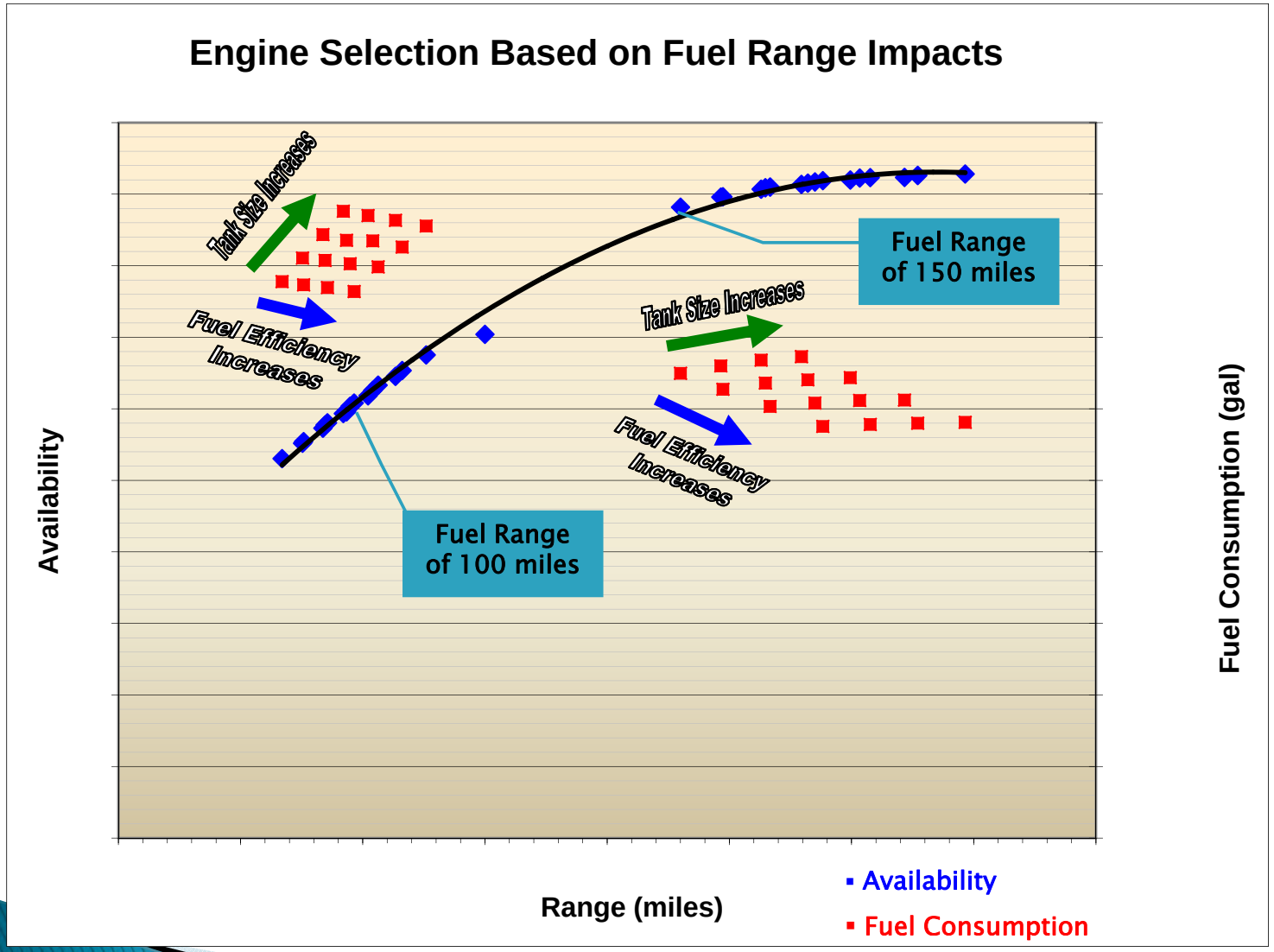




Program Improvement Phases

- Continuous pressure to improve performance of fielded systems is a reality
- There is a desire to reap potential benefits by deploying new technology advances
- MSA can assist decision makers in evaluating the effect deployment of new technologies will have on fielded systems
- Example: Engine upgrade evaluation

Engine Upgrade Evaluation Example



- This example measures a new 100 mile fuel range engine against a 150 mile range engine
- Each engine is analyzed with varied changes in tank size and fuel efficiency
- Availability and fuel consumption are the metrics used for this analysis

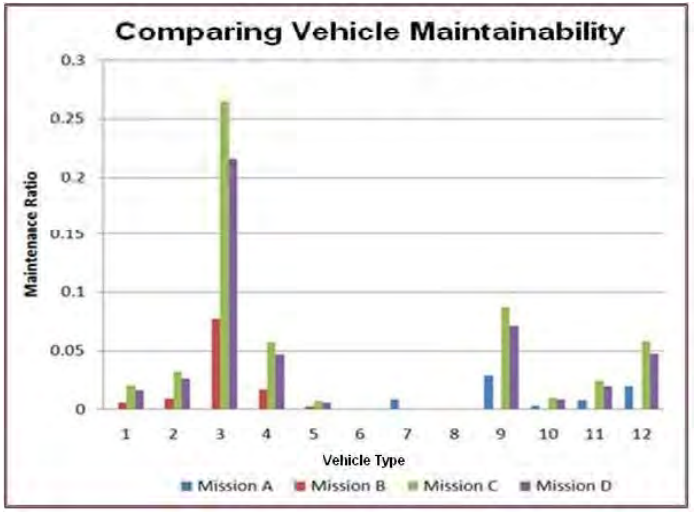
Goal: Evaluate new engine technology against operational metrics

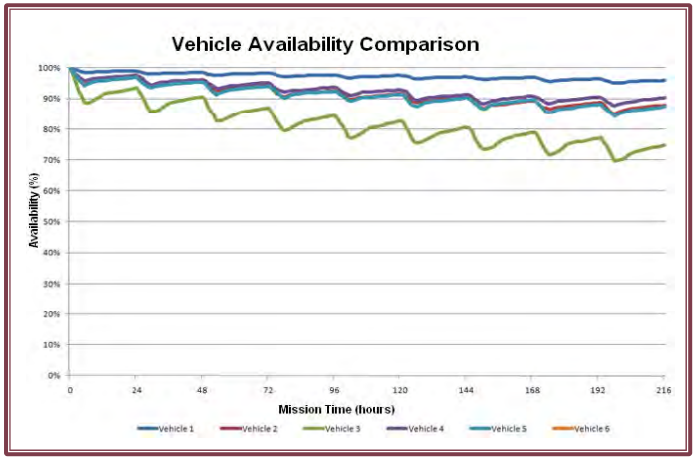
Retirement Phase

- MSA can assist decision makers in determining which systems to remove from field operations by evaluating contribution of system on overall SoS performance
  - Quantitative analysis of various performance attributes across the fleet of vehicles
  - Qualitative assessments of relative importance of each performance attribute
- Optimization and planning tools can also assist in formulating a retirement schedule
- Example: Fleet Management Analysis

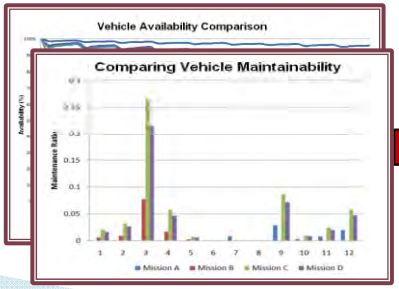
Fleet Management Analysis

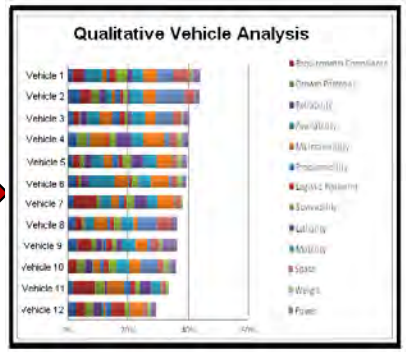
- Objective: Develop analysis framework to support decisions concerning the management of a large fleet of vehicles
- Use MSA to evaluate vehicle/fleet performance parameters
  - Maintainability
  - Availability
- Multi-objective fleet management optimization
  - Proper fleet composition and allocation for future requirements
  - Decisions about vehicle recap/reset/retirement
- Model constraints
  - Budget
  - Force structure requirements
  - Theatre or mission requirements
  - Vehicle Performance requirements
- Key Outputs
  - Number of vehicles by type to purchase or recap/reset/retire over time
  - Allocation of vehicles to theaters or missions based on performance

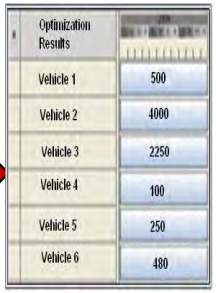




Optimization and Decision Analysis Framework







Conclusions

- Benefits from early investment in model development and MSA are gained throughout a system's life cycle
- MSA can save millions by helping to set realistic design requirements
- Continuous model refinement and use of simulation and analysis during system field use provides on-going benefits
- MSA can further assist decision makers by providing quantitative evidence to support program improvement and phase-out decisions